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Natural Resource Stewardship and Science

Southeast Alaska Network Freshwater Water Quality Monitoring Program

2014 Annual Report

Natural Resource Report NPS/SEAN/NRR—2015/927

ON THE COVER
The Salmon River water quality sonde serenely collects hourly data, gleefully anticipating the approaching sunlight
Photograph courtesy of John Rodstrom/National Park Service

Southeast Alaska Network Freshwater Water Quality Monitoring Program

2014 Annual Report

Natural Resource Report NPS/SEAN/NRR—2015/927

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Executive Summary

Freshwater water quality is an indicator of aquatic and terrestrial ecosystem health and one of twelve priority Vital Signs in the National Park Service's Southeast Alaska Network (SEAN), which includes Glacier Bay National Park and Preserve, Klondike Gold Rush National Historical Park, and Sitka National Historical Park. Data collected under this program inform several management-relevant topics:

- Assessing whether state and federal water quality standards are exceeded
- Measuring the *natural* quality of wilderness lands in Glacier Bay
- Describing effects of a changing climate on the physical and chemical properties of park waters (For example, how do changes in glacial watershed coverage, wetland water filling patterns, or forest cover affect long-term water quality patterns?)

This fifth annual report is intended to be a concise data summary and regular product for park staff, managers, superintendents, and other interested parties. All annual reports and data products are publicly available at the SEAN website:

http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx

In 2014, hourly water temperature, specific conductance, dissolved oxygen, and pH data were collected in the Salmon River (Glacier Bay) from April 18 through November 13, and in the Indian River (Sitka) from April 30 through September 25. The same parameters plus turbidity were collected in the Taiya River (Klondike Gold Rush) from April 7 through November 14. No observations signaled point source pollution or a change to the fundamental water quality of the three rivers.

Compared to previous monitoring seasons, water temperatures collected in 2014 were generally warmer than previous monitoring years 2010 through 2013, but not of concern. Daily mean temperature for the Salmon River ranged from 3.8 to 11.7°C, while the Indian River ranged from 5.5 to 10.8°C. Both rivers peaked in temperature on August 10. Daily mean temperature for the glacially influenced Taiya River ranged from 1.9 to 6.6°C and peaked on August 3 and September 17. Taiya River hourly turbidity measurements ranged from 0 to greater than 1,000 NTU and were synchronized with high flow events.

Patterns in the medians and distributions of specific conductance, dissolved oxygen, and pH were similar to previously observed ranges for all three rivers. The low dissolved oxygen conditions of the Indian River observed during summer 2013 were not repeated in 2014, likely due to more frequent rainfall, slightly lower water temperatures in August, and reduced abundance of spawning pink salmon.

During September 2014, partners from the University of Alaska Southeast installed 9 temporary stream temperature loggers throughout Glacier Bay to test the feasibility of year-round monitoring. The results of this one-year pilot project will be assessed over the next two years and may contribute to an expanded water temperature monitoring program for the SEAN.

Acknowledgments

This work could not be accomplished without the annual support of park staff. M. Bower, B. Carter, F. Hately, T. Hernandez, T. Kucerovy, C. Murdoch, J. Rodstrom, C. Thole, and J. Wilbarger efficiently conducted field work and transmitted data for processing. The SEAN Vital Signs program is supported by funding from the NPS National Inventory and Monitoring Program and the NPS Water Resources Division.

List of Acronyms and Abbreviations

°C	Degrees Celsius
cfs	Cubic feet per second
DO	Dissolved oxygen
GLBA	Glacier Bay National Park and Preserve
GRO	Global Rivers Observatory
KLGO	Klondike Gold Rush National Historical Park
m^3/s	Cubic meters per second
mg/L	Milligrams per liter
mS/cm	Milli-Siemens per centimeter
NPS	National Park Service
NTU	Nephelometric Turbidity Units
SEAN	Southeast Alaska Network
SITK	Sitka National Historical Park
SOP	Standard Operating Procedure
USGS	United States Geological Survey

Introduction

Water quality is an indicator of aquatic and terrestrial ecosystem health in Southeast Alaska, a rainforest landscape dominated by a wet and mild maritime climate. The Southeast Alaska Network (SEAN; Figure 1) of the National Park Service (NPS) has prioritized Freshwater Water Quality as one of 12 Vital Signs for long-term ecological monitoring based on its vulnerability to alteration by human stressors and sensitivity for detecting fundamental environmental changes (Moynahan et al. 2008). Trends in water quality can signify chronic or developing watershed issues within national parks.

The SEAN water quality monitoring program has the following objectives:

- Track the status and trends of each core water quality parameter (specific conductance, dissolved oxygen, pH, and water temperature; plus turbidity in the Taiya River) for at least one river in each SEAN park unit
- Describe the timing and magnitude of seasonal and annual variation for each core water quality parameter
- Evaluate whether state and/or federal water quality standards are met or exceeded

The SEAN water quality monitoring protocol (Sergeant et al. 2013) includes an extended description of each water quality parameter in Section 1.6. Briefly, specific conductance measures the ability of water to conduct an electrical current at a standardized temperature of 25°C. In Southeast Alaska, higher values generally represent groundwater influence and lower values represent rain and snow runoff. Dissolved oxygen (DO) is a measure of the amount of microscopic oxygen bubbles in water and is essential for aquatic organism respiration. DO is mainly regulated by temperature, but fluctuations in DO can be caused by other factors such as organic matter accumulation, biological decomposition, and water aeration. The pH of water is a unit-less measure of hydrogen ion concentration reflecting relative acidity or alkalinity; it affects aquatic organism respiration, salt exchange, and many biogeochemical processes. Turbidity is a measure of water clarity; increases in Taiya River turbidity usually signal glacial runoff.

This report concisely summarizes results from the 2014 sampling season and compares it with data collected since 2010. After the completion of the 2015 field season, a five-year synthesis report will present more in-depth trend analyses and broadened discussion. Guidance for annual report formatting and analysis is described in Standard Operating Procedure (SOP) 10 of the water quality monitoring protocol (Sergeant et al. 2013).

Study areas

The sampling goal of this monitoring program is to track water quality status and trends in at least one river in each of the three SEAN parks. In 2010, sonde locations were finalized for the Salmon (GLBA) and Indian (SITK) Rivers. The Taiya River (KLGO) was added in 2011. Sampling sites were chosen based on individual park interests and dependable long-term site access. Until the SEAN freshwater water quality monitoring program began, no consistent or long-term data were available for these three rivers (Eckert et al. 2006a; Eckert et al. 2006b; Hood et al. 2006).

Salmon River (GLBA)

GLBA, the largest park unit in the SEAN, has more than 310 streams (Soiseth and Milner 1995) flowing for over 3,380 km through a diverse landscape. Upstream of the water quality monitoring station, the Salmon River is 32.7 km long within a 9,600 ha watershed that collects most of its water from Excursion Ridge (Figure 1A). The water quality monitoring site is located on the river left bank at approximately river km 9.0 (Figure 1A) several meters upstream of the NPS boundary. The lowermost portion of the river (river km 0.0 to 9.0) is outside of NPS boundaries and within the town of Gustavus. The Salmon River has gravel riverbed habitat and supports populations of gamefish species such as pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*), cutthroat trout (*O. clarkii*), and Dolly Varden (*Salvelinus malma*; Eckert et al. 2006a). Staghorn (*Leptocottus armatus*) and coastrange sculpin (*Cottus aleuticus*) have been observed in the river (C. Soiseth, personal communication).

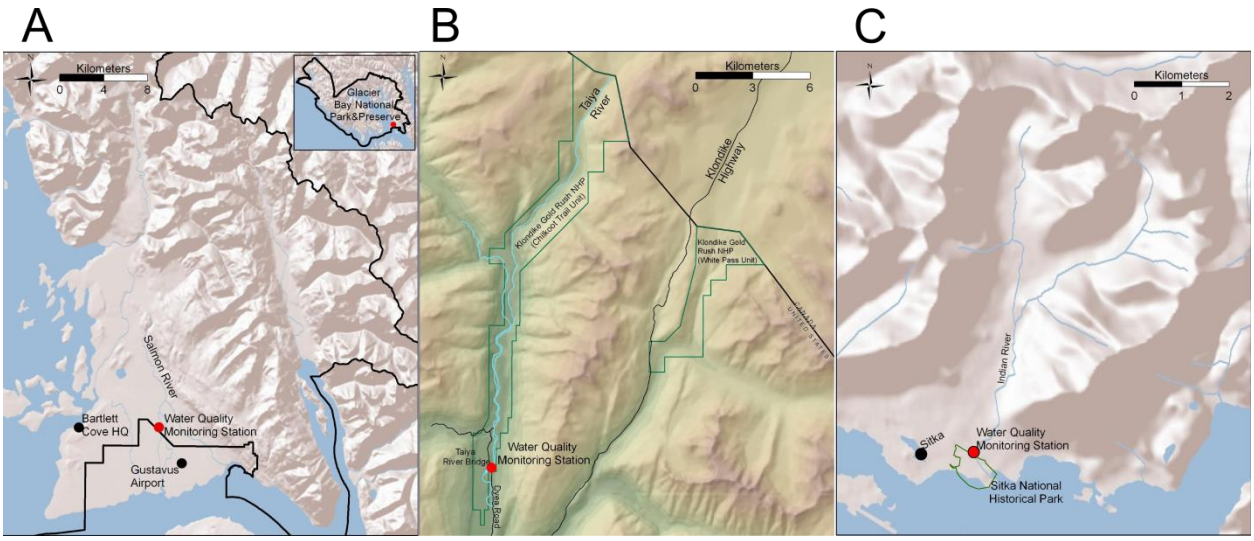
Taiya River (KLGO)

The Taiya River is located west of Skagway and one of two major drainages flowing through KLGO. Upstream of the water quality monitoring station, the Taiya River is approximately 25.7 km long and drains approximately 45,500 ha (Figure 1B). The water quality monitoring site is located on the river left bank slightly downstream of the Taiya River Bridge (Figure 1B) and adjacent to the United States Geological Survey (USGS) streamflow gaging site. From 1970 to 2014, the annual mean discharge from the Taiya River has ranged from a minimum of 24.9 m^3/s (880 cfs) in 1973 to 43.6 m^3/s (1,540 cfs) in 2013. Peak flows typically occur in August and September (USGS website for Taiya River gage 15056210: http://waterdata.usgs.gov/nwis/nwisman/?site_no=15056210&agency_cd=USGS).

Skagway is notably drier than other Southeast Alaska communities, averaging 74 cm of precipitation per year, in comparison to 142 cm in Gustavus and 219 cm in Sitka (Western Regional Climate Center Data: http://www.wrcc.dri.edu/summary/Climsmak.html). The glacial influence on the Taiya watershed is unique among streams currently monitored in the SEAN. As of 2001, approximately 36% of the watershed was covered by glaciers (Sergeant and Nagorski 2014). Glacial outburst events have led to large floods and created a highly dynamic physical environment (Hood et al. 2006). The Taiya watershed supports chum, pink, and coho salmon populations, as well as Dolly Varden. Eulachon (*Thaleichthys pacificus*) have been reported to run up the Taiya River in the spring (Hood et al. 2006).

Indian River (SITK)

The lowest 1 km of the Indian River is the only significant freshwater habitat within SITK and can be characterized as a low gradient alluvial channel with gravel-cobble substrate that supports anadromous fish species, including coho, pink, chum, and Chinook salmon (*O. tshawytscha*), steelhead, Dolly Varden, and non-anadromous species such as resident rainbow trout (*O. mykiss*), three-spine stickleback (*Gasterosteus aculeatus*), and coastrange sculpin (Eckert et al. 2006b). Upstream of the water quality monitoring site, the Indian River is approximately 19.8 km long within a steep and well-drained 3,100 ha watershed (Figure 1C). The monitoring site is located on the river right bank approximately 60 m upstream of park boundaries at river km 0.8 (Figure 1C).



River	Watershed (km^2)	Length (km)	Max. elevation (m)	Glacier (%)	Wetland (%)	Forest (%)	Sampling site (river km)
Salmon	96	32.7	1079	0	37	44	9
Taiya	455	25.7	1829	36	2	20	3.5
Indian	31	19.8	1158	1	18	55	0.8

Figure 1. The three SEAN water quality monitoring station locations (solid red circles) and their associated watershed characteristics. (A) Salmon River in GLBA; black line denotes park boundary (B) Taiya River in KLGO; green lines denote park boundaries (the park units are not contiguous) (C) Indian River in SITK slightly upstream of park boundary; green line denotes park boundaries. Watershed characteristics were measured for the areas upstream of each monitoring station (data adapted from Sergeant and Nagorski 2014).

Methods

Station instrumentation

The Salmon, Taiya, and Indian Rivers were sampled hourly for specific conductance (mS/cm), dissolved oxygen (mg/L), pH, and water temperature (°C). Additionally, turbidity (NTU) was measured in the Taiya River. Multi-parameter water quality sondes (Table 1) collected and logged data at single fixed sites in the Salmon River from April 18 through November 13, the Taiya River from April 7 through November 14, and the Indian River from April 30 through September 25

(Figure 1; Table 2). Each year, sampling is planned to occur from at least May 1 through October 31, and extends into November if ice conditions and staff resources allow.

Table 1. YSI, Inc. instruments used for 2014 water quality sampling.

Equipment description	Model number
Multi-parameter water quality logger	6920V2-2
Multi-parameter display system	650
Conductivity/temperature probe	6560
pH probe	6561
Optical oxygen sensor	6150
Optical turbidity sensor	6136

In all three rivers, a sonde was mounted inside a perforated 4-inch ABS pipe. In the Salmon River the pipe was attached to an angle-iron rod set in the streambed, while in the Taiya and Indian Rivers the pipe was bolted to a large boulder in the stream channel. A bolt mounted through the ABS pipe set the sonde height in the water column. After sondes were installed, Park Leads visited the sondes approximately once per month to check calibration for each sensor and clean components, as needed. These calibration checks were used to assess data quality and ensure that the water quality instruments were functioning properly.

Table 2. Summary of 2014 freshwater water quality sampling effort.

	Month								
River	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Core parameters collected?
Salmon									Y
Taiya									Y[1]
Indian									Y[2]

Full month

Partial month

[1] from September 18 to November 14, DO sensor did not log data

[2] pH sensor failed on July 7 through and replaced August 15

Data processing

This report follows guidance provided in the SEAN monitoring protocol FQ-2013.1 (Sergeant et al. 2013). The protocol narrative and SOPs 1 through 3 describe the data collection, monthly error/calibration checks, and data processing in detail (Sergeant et al. 2013). Park and SEAN staff generally conducted error/calibration checks monthly at each water quality station from May through November (Table 3). The early September maintenance check for the Indian River sonde was not completed due to lack of available staff.

The SEAN has established data "ratings" and "grades" to describe overall data quality. Data ratings denote unusable data for reasons such as the sonde being out of water during an error/calibration check or an erroneous value due to instrument malfunction. Before analysis, data with a '2' or '3' rating were removed from the dataset. Data with '0' (no question of accuracy) or '1' (determined useable by Project Leader despite potential mistakes in precisely following protocols) ratings were used for analysis. SOP 13 of the water quality protocol (Sergeant et al. 2013) describes each data rating in detail. Comments contained in the water quality database are available on the SEAN website (http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx) and contain explanations for each assigned rating other than zero.

Data grades refer to the point-in-time accuracy of each water quality sensor during regular error/calibration checks and range from 'Poor' to 'Excellent'. The grades determined by these point checks were back-dated to the previous error/calibration check and applied to all data during that time period. Due to its subjectivity, the SEAN does not correct (adjust) data values based on error/calibration checks (as described in Wagner et al. 2006), but sensor values from calibration checks are available by downloading field sheets from the SEAN website (http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx) and allow future data users to perform corrections if deemed appropriate.

The final datasets were analyzed and summarized according to the guidelines in SOP 10 (Sergeant et al. 2013).

Results

Data collection

2014 water quality measurements were generally high quality, but several issues were encountered with continuous data collection on the Taiya and Indian Rivers. Due to sensor failure, no DO data were collected for the Taiya River after September 18. Turbidity quality grades for the Taiya River ranged from Poor to Excellent. While the observed values were within reasonable sensor accuracy expectations, turbidity values are best used for relative seasonal trends in water clarity and less appropriate as absolute individual measurements. The pH sensor for the Indian River was approximated to fail around July 7, but was replaced on August 15. During a maintenance check of the Indian River sonde on September 25, a programming error resulted in no data being collected after that date.

Table 3. Summary of 2014 freshwater water quality data grades. E = Excellent, G = Good, F = Fair, P = Poor. Definitions for each grade are found in SOP 2 (Sergeant et al. 2013) and are based on USGS recommendations (Wagner et al. 2006). Shaded areas represent periods when data grades are not available due to sensor malfunction. SC = specific conductance; DO = dissolved oxygen.

		Date ranges							
River	**Parameter**	**4/18-6/2**	**6/2-7/2**	**7/2-7/30**	**7/30-9/3**	**9/3-9/30**	**9/30-11/5**	**11/5-11/13**	
Salmon	SC (mS/cm)	E	E	E	E	E	E	E	
	DO (mg/L)	E	E	E	E	E	E	E	
	pH	E	E	E	E	E	E	E	
	Temperature (°C)	G	E	E	E	E	F	E	
		4/7-5/2	**5/2-6/2**	**6/2-7/3**	**7/3-8/4**	**8/4-9/11**	**9/11-10/7**	**10/7-11/4**	**11/4-11/14**
Taiya	SC (µS/cm)	P	P	G	E	E	E	E	E
	DO (mg/L)	E	E	E	E	E			
	pH	E	E	E	E	E	E	E	E
	Temperature (°C)	G	E	F	E	E	P	P	E
	Turbidity (NTU)	P	P	F	E	P	P	E	E
		4/30-6/11	**6/11-7/7**	**7/7-8/1**	**8/1-9/25**				
Indian	SC (µS/cm)	G	G	E	E				
	DO (mg/L)	E	E	E	E				
	pH	E	E		P				
	Temperature (°C)	G	F	F	E				

Comprehensive time series data

Hourly time series data for all water quality parameters in all three rivers are included in Appendix A. Daily average streamflow time series data from the Taiya River is compared to daily average water quality data in Appendix B. Indian River daily streamflow and water quality comparisons are in Appendix C. Indian River streamflow is reported as relative stage height because a current discharge-stage relationship is under development by the SEAN and local program partners. In both rivers, streamflow data was collected in the same location as water quality data. At the time of this report, USGS has installed a streamflow gage for the Salmon River, but data are not yet available for download.

Salmon River

Temperature

In comparison to average daily mean values from 2010-2013, 2014 water temperatures were generally warmer than previous years (Figure 2), but this result should be interpreted with caution because of the short time series available. During the period of monitoring, The daily mean water temperature in the Salmon River ranged from 3.8 to 11.7°C (Table 4) and peaked on August 10 (2010-2013 average peak temperature date = August 10, standard deviation = 19 days). Median daily mean water temperature during the monitoring period was 7.8°C. Monthly mean daily average temperatures ranged from 5.4 to 9.8°C (Table 4). Variation in daily mean temperatures was nearly equal across all months (Table 4).

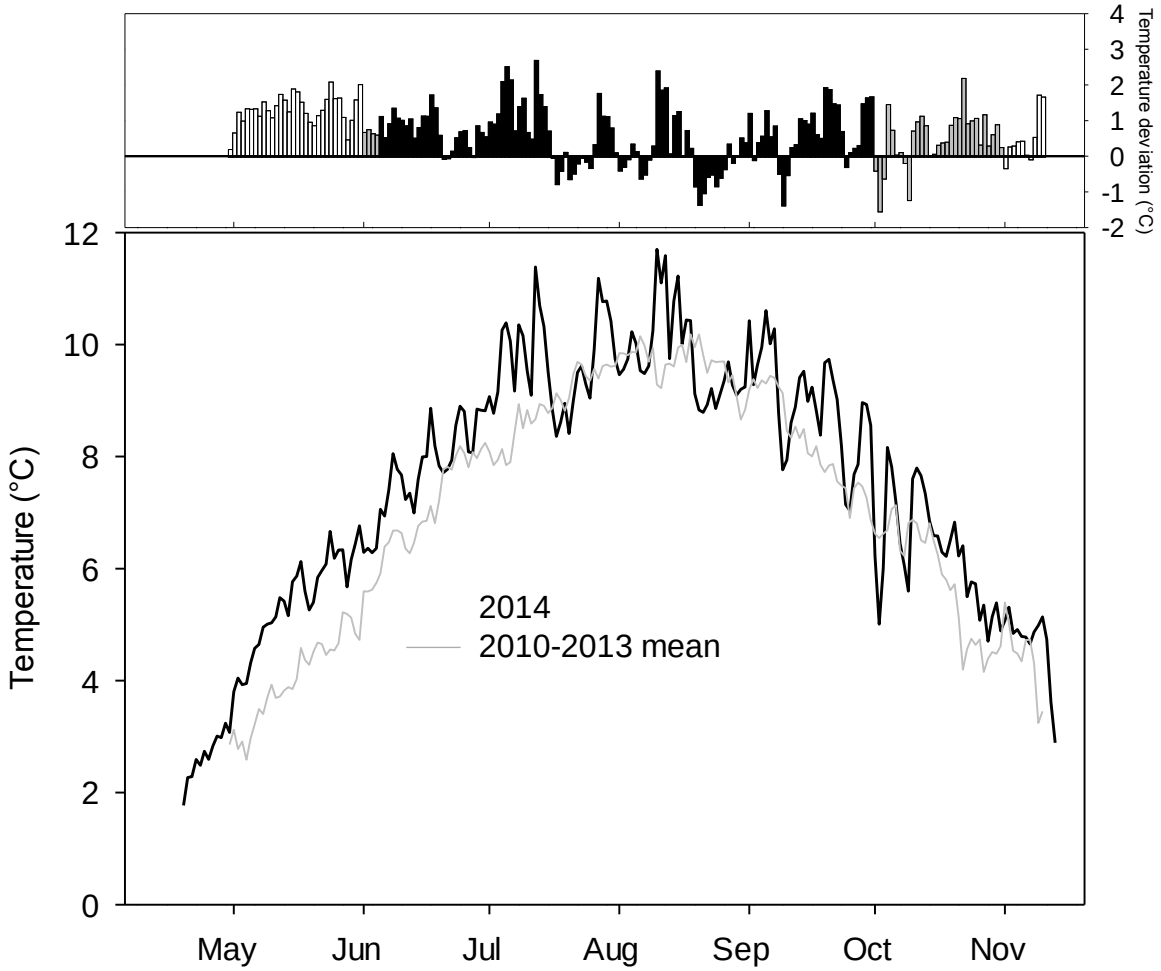


Figure 2. Daily mean water temperature for the Salmon River in 2014 and 2010-2013 mean (lower panel) and temperature deviations from 2010-2013 mean (upper thin panel). In the upper panel, deviations were compared against average daily temperatures calculated using 2 years of historical data (white bars), 3 years (gray bars), or 4 years (black bars). Due to the short time series, interpret deviations cautiously.

Table 4. Monthly mean, minimum daily mean, and maximum daily mean water temperature for the Salmon, Taiya, and Indian Rivers in 2014. Only months with at least 75% of total monthly hours measured were included. See the Methods section for sonde installation dates for each river.

	Salmon			Taiya			Indian		
Month	**Mean daily average (SD)**	**Min**	**Max**	**Mean daily average (SD)**	**Min**	**Max**	**Mean daily average (SD)**	**Min**	**Max**
April				3.2 (0.6)	1.9	4.1			
May	5.4 (0.8)	3.8	6.8	4.5 (0.6)	3.5	5.7	6.6 (0.6)	5.5	7.6
June	7.8 (0.8)	6.3	8.9	5.8 (0.4)	5.0	6.5	7.4 (0.2)	7.0	7.7
July	9.7 (0.8)	8.4	11.4	5.9 (0.3)	5.5	6.6	8.5 (0.5)	7.5	9.3
August	9.8 (0.8)	8.8	11.7	5.8 (0.3)	5.4	6.4	9.0 (0.7)	7.8	10.8
September	9.0 (0.9)	7.0	10.6	5.6 (0.4)	4.9	6.6	8.8 (0.7)	7.9	10.2
October	6.3 (0.9)	4.7	8.2	4.3 (0.5)	3.1	5.1			

Specific conductance, DO, and pH

The 2014 ranges for specific conductance and pH values in the Salmon River (Figure 3) were generally similar to 2013, which had a similar data collection time frame. Individual specific conductance measurements ranged from 0.05 to 0.35 mS/cm with a median of 0.20 mS/cm (Figure 3). DO ranged from 8.2 to 13.1 mg/L with a median of 10.1 mg/L (Figure 3). DO reached the minimum observed value on July 24. Values for pH ranged from 7.2 to 8.0 with a median of 7.8 (Figure 3).

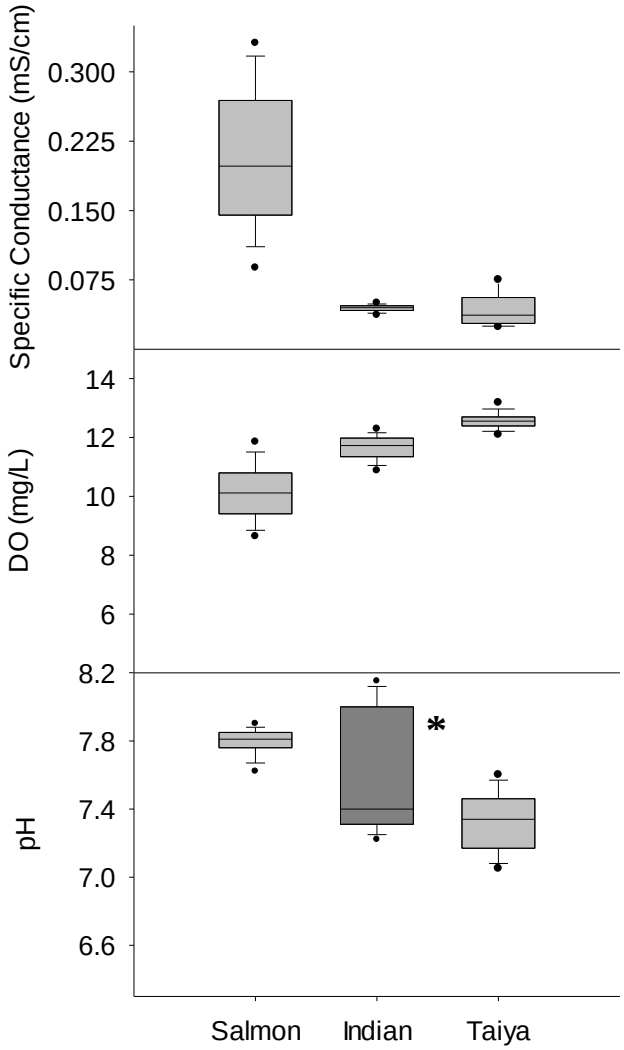


Figure 3. Box plots summarizing all valid measurements for pH, dissolved oxygen (DO), and specific conductance for the Salmon, Taiya, and Indian Rivers in 2014. The horizontal line within each box indicates median values, horizontal lines bounding the upper and lower portion of the boxes represent 25th and 75th percentiles, lower and upper whiskers represent 10th and 90th percentiles, and single points represent 5th and 95th percentiles.

* pH values for the Indian River should be interpreted with caution, as the replacement sensor installed between August 15 and September 25 was not recording high accuracy measurements. On September 25, the pH sensor was checked against standards and reading approximately 1 unit higher than standards (note the 'poor' data grade in Table 3). Data from this period will likely need to be corrected for future analyses.

Taiya River

Temperature

In comparison to average daily mean values from 2011-2013, 2014 water temperature was warmer than average, most notably in early summer and fall (Figure 4), but this result should be interpreted with caution because of the short time series available. During the period of monitoring, The daily mean water temperature in the Taiya River ranged from 1.9 to 6.6°C (Table 4) and peaked on August 3 and September 17 (2011-2013 average peak temperature date = July 27, standard deviation = 4 days). Median daily mean water temperature during the monitoring period was 5.4°C. Monthly mean daily average temperatures ranged from 3.2 to 5.9°C (Table 4).

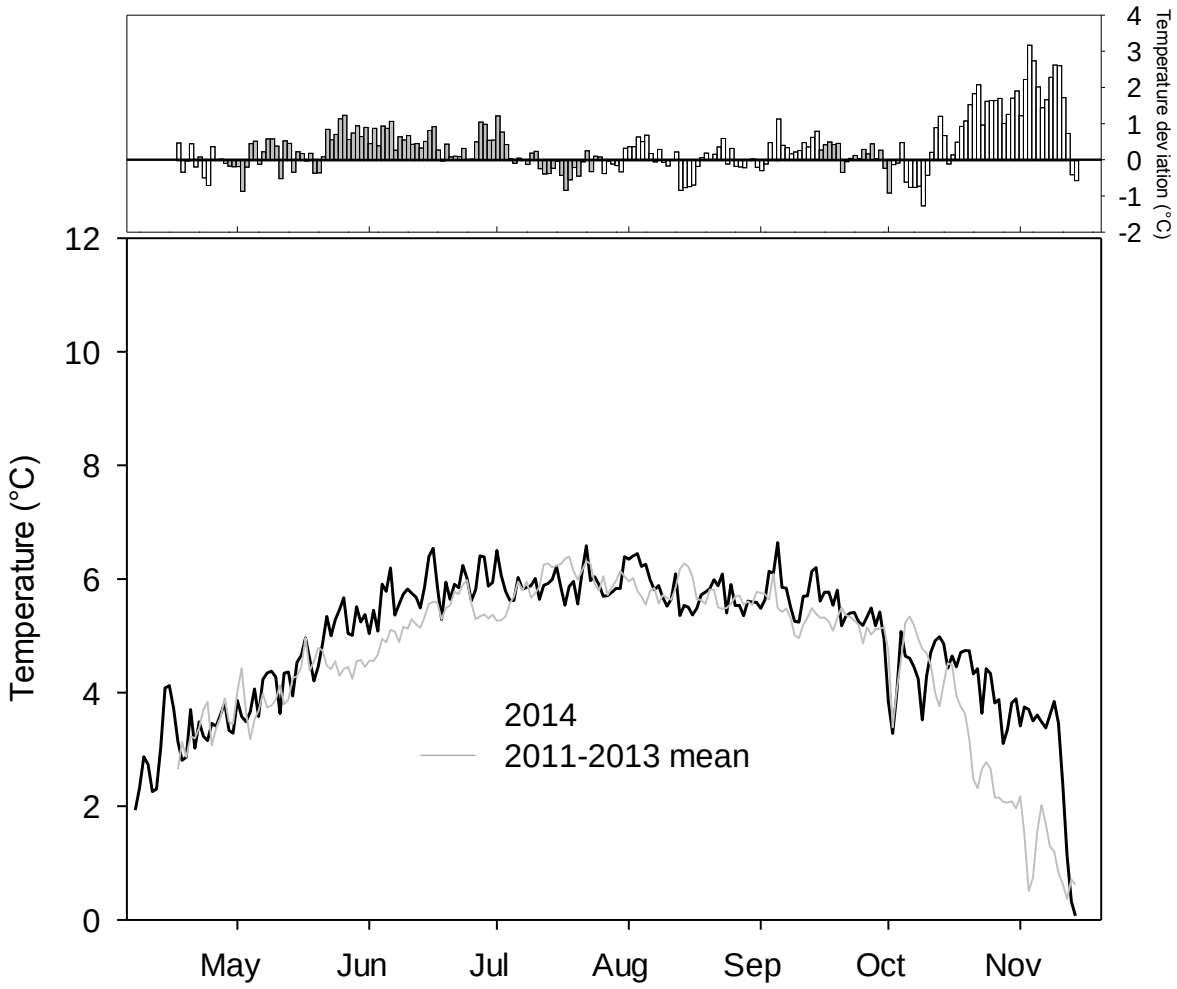


Figure 4. Daily mean water temperature for the Taiya River in 2014 and 2011-2013 mean (lower panel) and temperature deviations from 2011-2013 mean (upper thin panel). In the upper panel, deviations were compared against average daily temperatures calculated using 2 years of historical data (white bars) or 3 years (gray bars). Due to the short time series, interpret deviations cautiously.

Turbidity

In 2014, Taiya River hourly turbidity measurements ranged from 0 to greater than 1,000 NTU (the turbidity sensor maximum) during the sampling season, with the largest peak event occurring in mid-August (Figure 5). The daily mean turbidity maximum was 662 NTU. Turbidity spikes began in mid-May and continued through mid-October. Turbidity events were consistently timed with high flow events caused by increased input of glacial melt water (Appendix B; Figure 10).

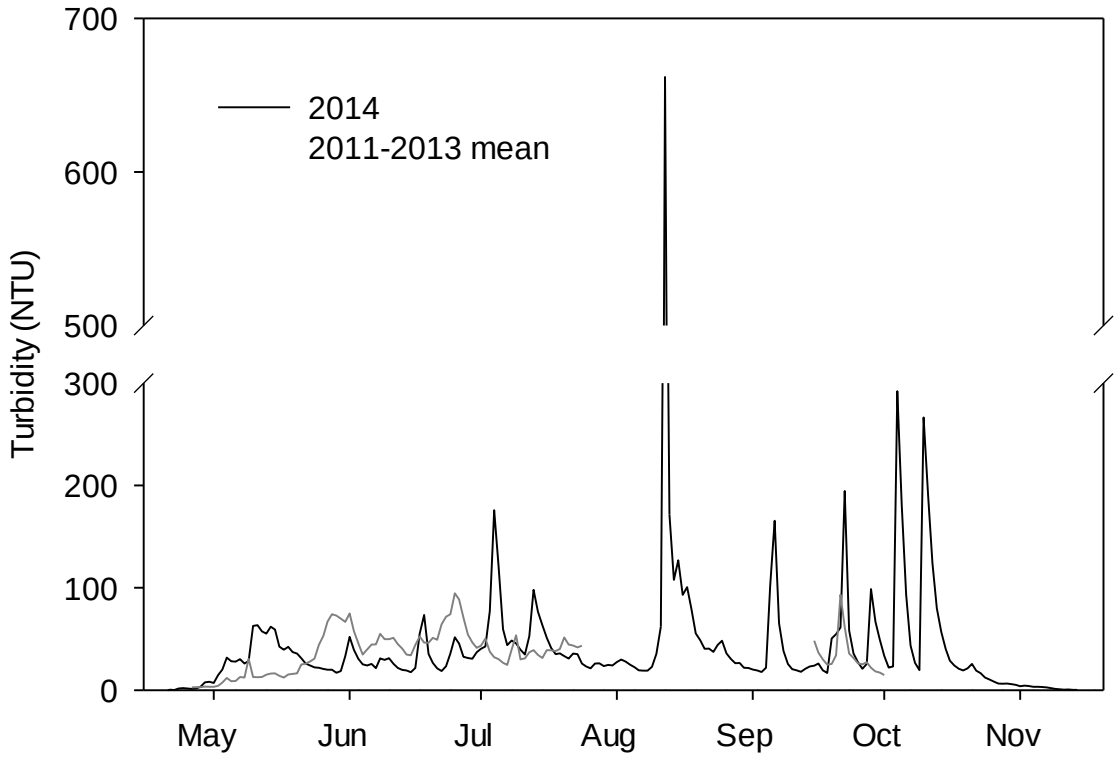


Figure 5. Daily mean turbidity for the Taiya River in 2014 and averaged across commonly measured dates in 2011-2013.

Specific conductance, DO, and pH

In the Taiya River in 2014, individual specific conductance measurements ranged from 0.02 to 0.09 mS/cm with a median of 0.04 mS/cm (Figure 3). DO ranged from 11.5 to 13.7 mg/L with a median of 12.6 mg/L (Figure 3), but the DO sensor stopped reporting values on September 19 and was not recovered for the remaining monitoring season. Values for pH ranged from 6.9 to 7.7 with a median of 7.3 (Figure 3).

Indian River

Temperature

In comparison to average daily mean values from 2010-2013, 2014 water temperature was consistently warmer than average (Figure 6), but this result should be interpreted with caution because of the short time series available. During the period of monitoring, The daily mean water temperature in the Indian River ranged from 5.5 to 10.8°C (Table 4) and peaked on August 10 (2010-2013 average peak temperature date = August 23, standard deviation = 6 days). Median daily mean

water temperature during the monitoring period was 8.1°C. Monthly mean daily average temperatures ranged from 6.6 to 9.0°C (Table 4).

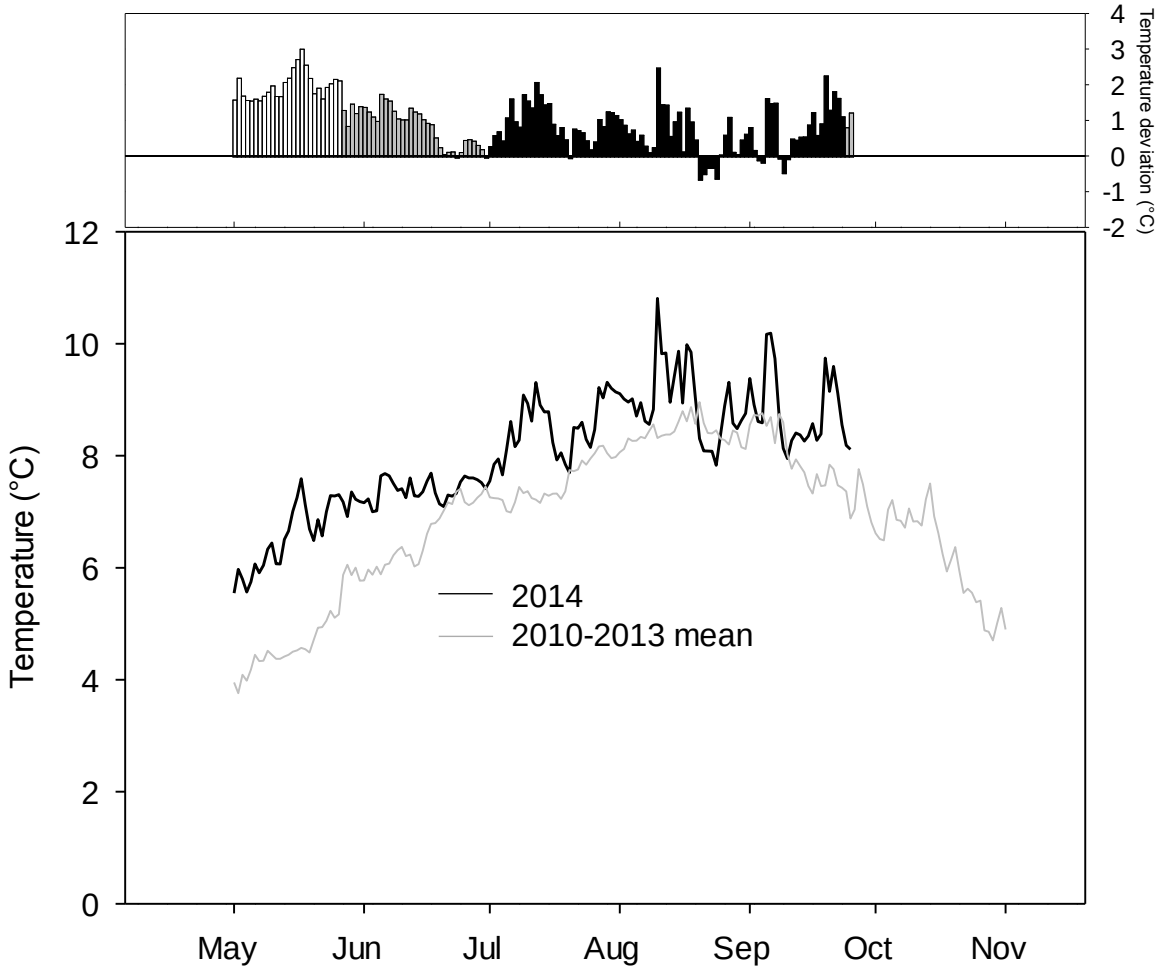


Figure 6. Daily mean water temperature for the Indian River in 2014 and 2010-2013 mean (lower panel) and temperature deviations from 2010-2013 mean (upper thin panel). In the upper panel, deviations were compared against average daily temperatures calculated using 2 years of historical data (white bars), 3 years (gray bars), or 4 years (black bars). Due to the short time series, interpret deviations cautiously.

Specific conductance, DO, and pH

In the Indian River, hourly specific conductance measurements ranged from 0.02 to 0.05 mS/cm with a median of 0.05 mS/cm. The critically low DO values observed during August 2013 (Sergeant and Johnson 2014) were not repeated during the summer of 2014. DO ranged from 9.4 to 12.8 mg/L with a median of 11.7 mg/L (Figure 3). The minimum DO value was reached on August 9. Values for pH ranged from 7.0 to 8.2 with a median of 7.4 (Figure 3). The pH time series should be interpreted with caution, as the replacement sensor installed between August 15 and September 25 may not have been displaying highly precise measurements. On September 25, the pH sensor was checked against

standards and reading approximately 1 unit higher (note the 'poor' data grade in Table 3). While the SEAN does not correct data for sensor drift, users of this period of data should consider corrections.

Compliance with water quality standards

No 2014 observations indicated exceedances of Alaska Department of Environmental Conservation water quality standards (Table 6; ADEC 2012) and water quality values in the three rivers never approached regulatory thresholds.

Table 5. Period of record and summary statistics for all freshwater water quality data collected and reported by the SEAN from 2010 through 2014.

				Summary statistics				
River	**Parameter**	**Period of Record**	**# obs.**[1]	**Median**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Salmon	Conductivity (mS/cm)	Jun 04, 2010 to Nov 13, 2014	20,491	0.19	0.20	0.07	0.00	0.44
	Dissolved Oxygen (mg/L)		20,495	10.4	10.4	1.0	7.9	15.5
	Dissolved Oxygen (% Sat)		20,495	86.9	86.8	6.3	70.4	110.0
	pH		19,752	7.8	7.8	0.1	7.1	8.1
	Temperature (°C)		21,131	7.8	7.5	2.3	0.7	12.8
Taiya	Conductivity (mS/cm)	Apr 25, 2011 to Nov 14, 2014	18,166	0.04	0.04	0.02	0.00	0.09
	Dissolved Oxygen (mg/L)		13,910	12.5	12.6	0.6	10.7	14.9
	Dissolved Oxygen (% Sat)		13,910	97.8	97.5	3.3	79.8	110.5
	pH		17,943	7.4	7.4	0.2	6.5	8.0
	Temperature (°C)		18,166	5.1	4.8	1.6	0.0	9.6
	Turbidity (NTU)		18,022	24.9	32.4	38.3	-1.7[2]	939.8
Indian	Conductivity (mS/cm)	May 26, 2010 to Sep 25, 2014	16,969	0.04	0.04	0.01	0.01	0.08
	Dissolved Oxygen (mg/L)		16,970	11.9	11.6	1.7	1.7	14.0
	Dissolved Oxygen (% Sat)		16,970	99.6	95.8	12.5	15.5	108.8
	pH		16,032	7.1	7.1	0.3	6.3	8.2
	Temperature (°C)		17,598	7.5	7.3	1.5	2.2	12.0

1 Data graded '2' or '3' were not counted as observations; Please see SOP 13 of the Freshwater Water Quality protocol (Sergeant et al. 2013) for descriptions of these water quality ratings.

2 Slightly negative turbidity values reflect inherent sensor imprecision

Table 6. Current Alaska Department of Environmental Conservation (ADEC) water quality standards, last amended April 8, 2012 (ADEC 2012). Superscript numbers denote the intended use category of water quality standard.

Parameter	Criteria
Specific conductance	None listed by ADEC
Dissolved oxygen (DO)[1]	DO must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may DO be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning. For waters not used by anadromous or resident fish, DO must be greater than or equal to 5 mg/l. In no case may DO be greater than 17 mg/l. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection.
pH[1,2]	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
Temperature[1,2]	May not exceed 20°C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes 15°C Spawning areas 13°C Rearing areas 15°C Egg & fry incubation 13°C For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.
Turbidity[3]	May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU. May not exceed 5 NTU above natural turbidity for all lake waters.

[1] Growth and propagation of fish, shellfish, other aquatic life, and wildlife
[2] Water supply/aquaculture
[3] Water recreation

Discussion

Observed trends

Across all three rivers monitored by the SEAN in 2014, no observed values or trends appeared to signal point source pollution or a fundamental change to existing water quality patterns. The critically low DO conditions of the Indian River observed during the summer of 2013 were not repeated in 2014, likely due to increased rainfall throughout the summer, slightly lower water temperature in August, and lower abundance of spawning pink salmon.

Program performance

In general, program operations were executed efficiently in 2014, but sensor malfunction and programming errors lead to several data gaps up to approximately one month (Table 2). Sensor malfunction is a common and usually unpreventable problem for water quality monitoring programs,

but to reduce human mistakes such as programming errors, the SEAN recommends continuing pre-installation training at the start of each season, even when previously experienced field leads are involved. Whenever possible, it is best to limit park staff to 1 or 2 water quality leads throughout a single monitoring season to maintain better consistency in data collection and quality. SEAN staff will continue maintaining close communication with park staff to develop feasible staffing solutions each season.

2014 marks 5 years of data collection for the Salmon and Indian Rivers, and 4 years for the Taiya River. After the completion of the 2015 season, a water quality synthesis report by SEAN staff will summarize multi-year trends, program performance, and future program needs or modifications.

Synergistic efforts

Year-round temperature monitoring remains an important expansion opportunity for the SEAN water quality monitoring program. Due to the low cost of temperature logging sensors and ease of installation and maintenance, an expanded network of temperature sensors across streams in all three parks is very feasible. During September 2014, partners from the University of Alaska Southeast installed 9 temporary stream temperature loggers throughout Glacier Bay to test the feasibility of year-round monitoring (see permit application at: https://irma.nps.gov/rprs/Permit/Profile/39631). SEAN staff assisted with guiding the project's scope within Glacier Bay and drafting permitting information. The results of this one-year pilot project will be assessed over the next two years and may contribute to an expanded water temperature monitoring program for the SEAN. The project will result in a master's thesis for one student at University of Alaska Fairbanks (M. Winfree, advised by E. Hood) assessing temperature trends throughout the southeastern Alaska region.

SEAN water quality data collected from the Indian River has been contributing to an environmental education project lead by the Sitka Conservation Society. Local youth are collecting and analyzing periodic water quality samples from the Indian River as part of a worldwide water chemistry monitoring program run by the Global Rivers Observatory (GRO). The SEAN data are often combined with GRO data to provide greater context and richer data for reporting.

The first peer-reviewed article using SEAN water quality data was published online by River Research and Applications in May 2014:

Sergeant, C. J., and S. A. Nagorski. 2014. The implications of monitoring frequency for describing riverine water quality regimes. River Research and Applications. DOI: 10.1002/rra.2767.

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Appendix A: Hourly time series by river for all water quality parameters

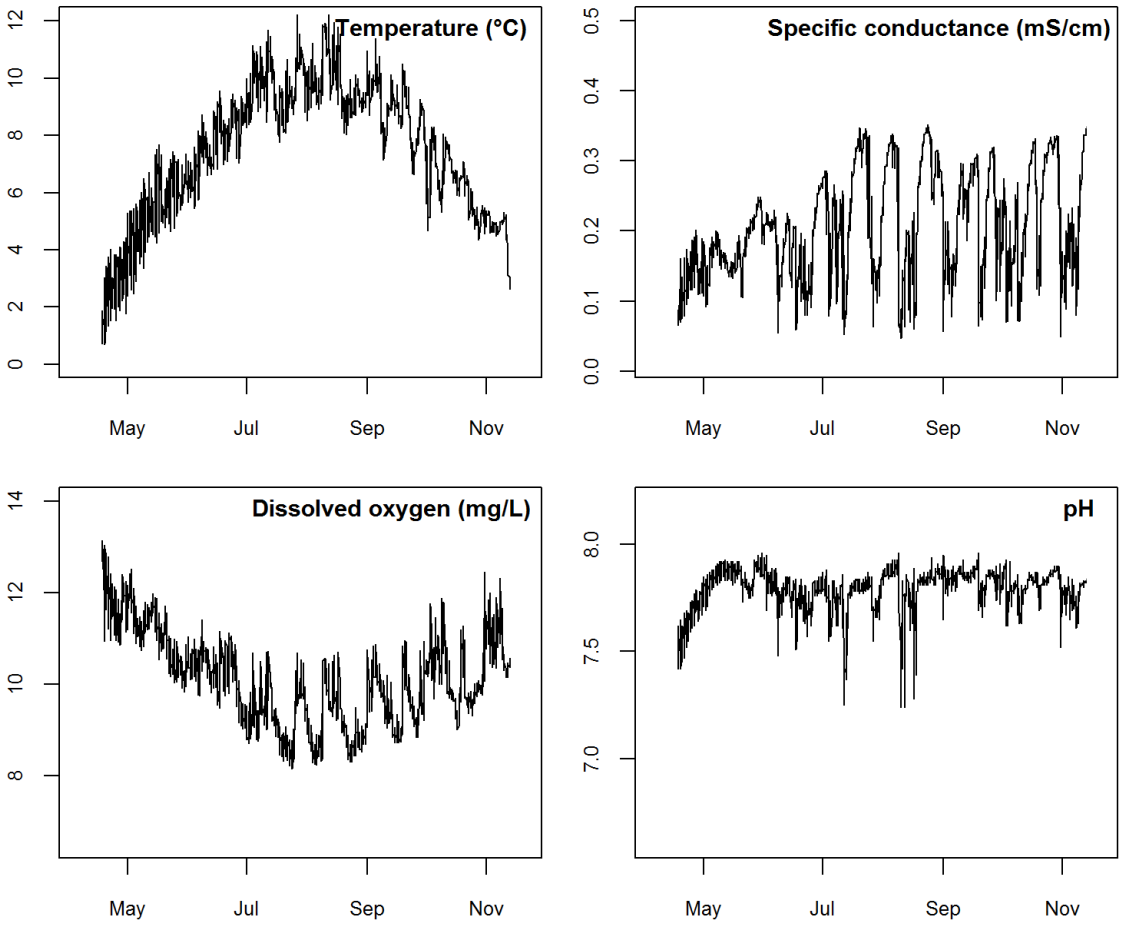

Figure 7. Hourly water quality data for the Salmon River in 2014.

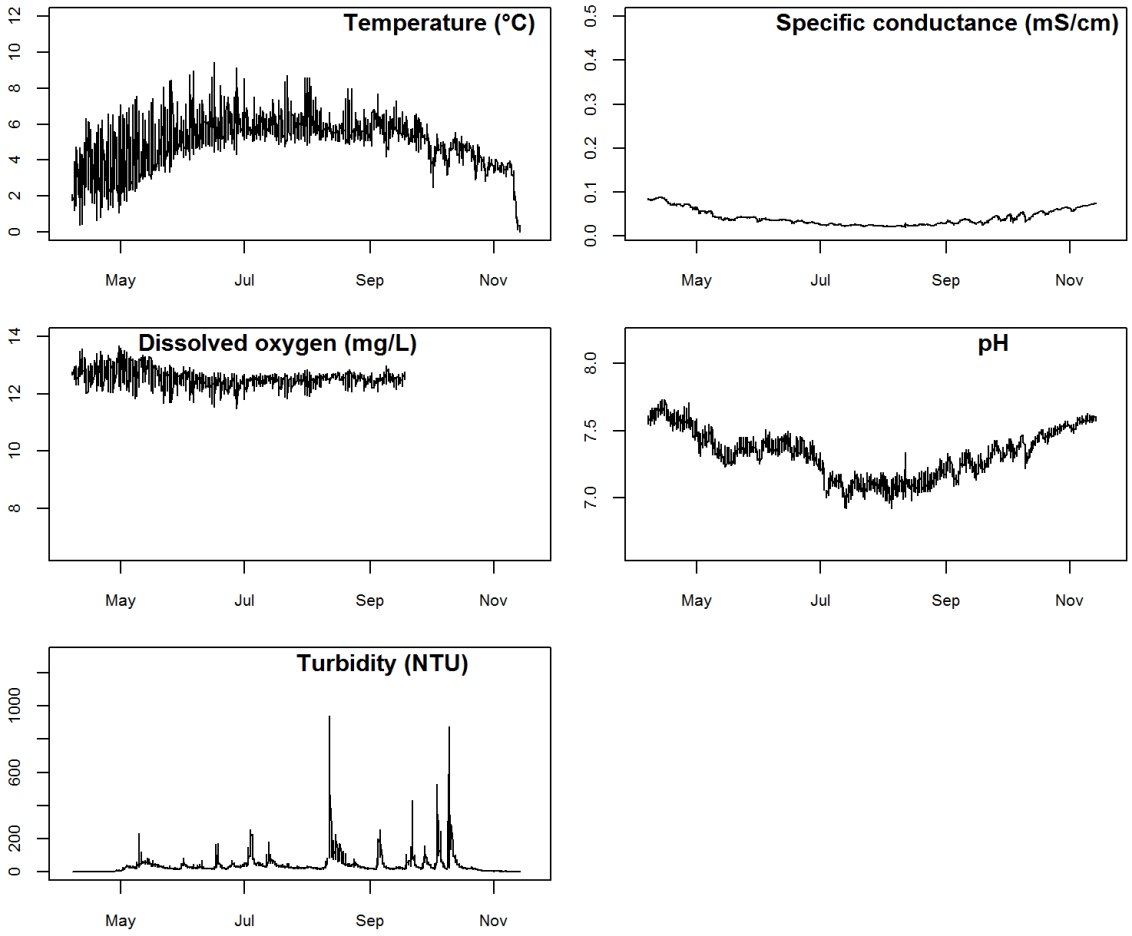

Figure 8. Hourly water quality data for the Taiya River in 2014.

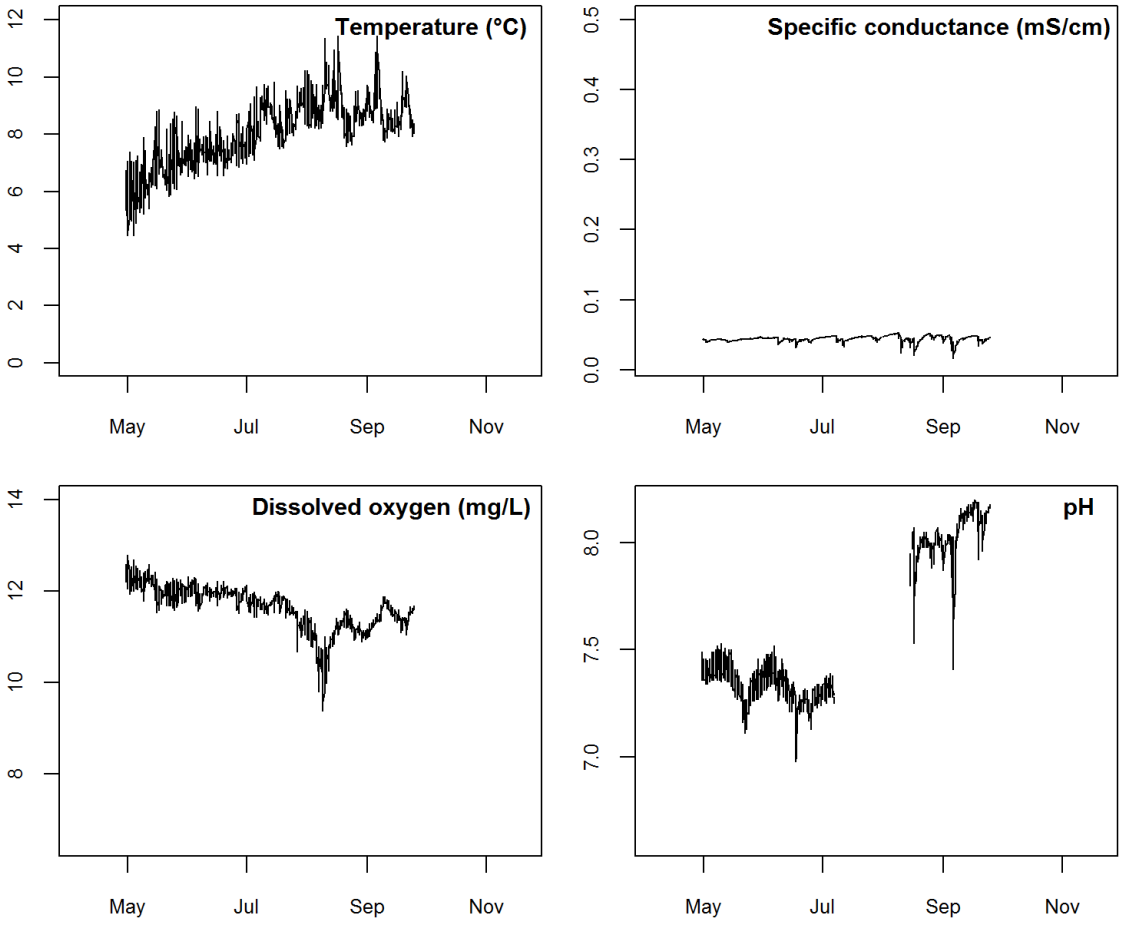

Figure 9. Hourly water quality data for the Indian River in 2014. See the Results section for a discussion of the data gap and accuracy of pH values.

Appendix B: Taiya River streamflow time series versus all water quality parameters

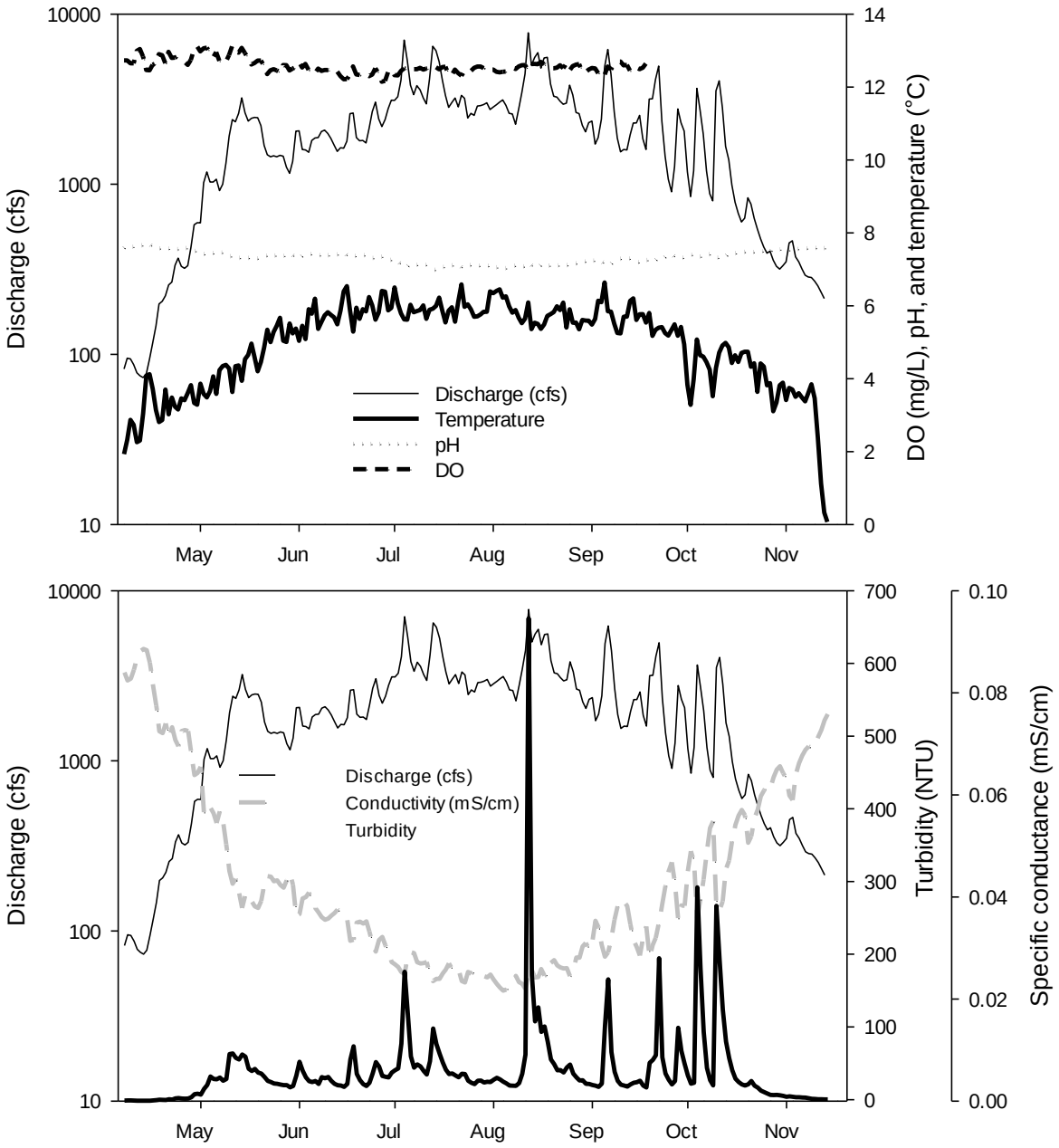

Figure 10. Daily average streamflow (log scale) versus daily averages for all water quality parameters in the Taiya River in 2014. Note the additional Y-axes on each panel. Streamflow data collected in the same location as water quality data and downloaded from the Taiya River USGS gage #1505621 website (http://waterdata.usgs.gov/ak/nwis/uv/?site_no=15056210&PARAmeter_cd=00065,00060).

Appendix C: Indian River stage height time series versus all water quality parameters

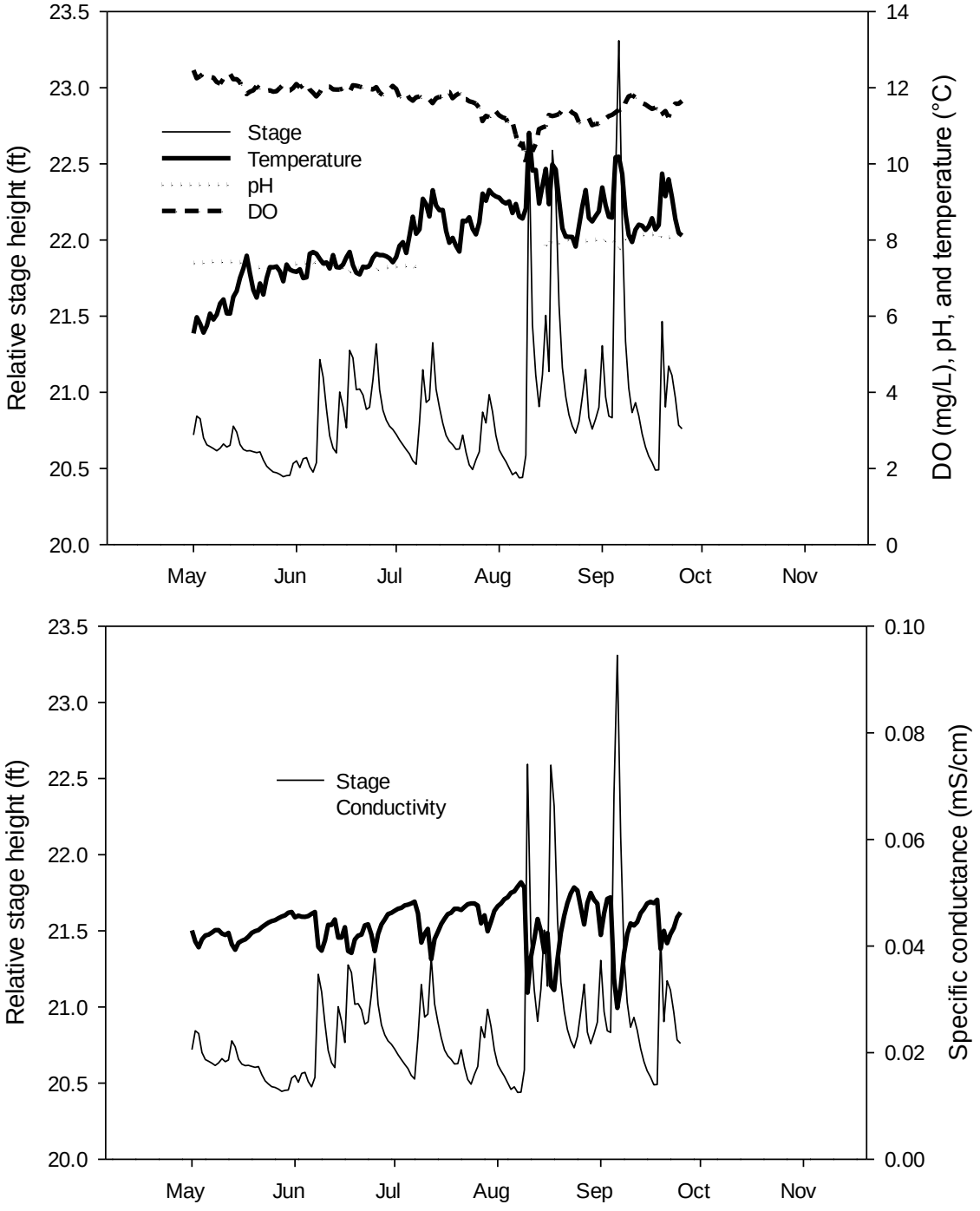

Figure 11. Daily average stage height versus daily averages for all water quality parameters in the Indian River in 2014. Note the additional Y-axes on each panel. Streamflow data collected in the same location as water quality data and housed with the SEAN. The SEAN is creating an Indian River streamflow protocol for long-term data collection and management. Real-time streamflow information can currently be viewed at: http://water.weather.gov/ahps2/hydrograph.php?wfo=pajk&gage=irva2&hydro_type=2 .

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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